The Journal

OF THE AMERICAN SOCIETY OF SAFETY ENGINEERS

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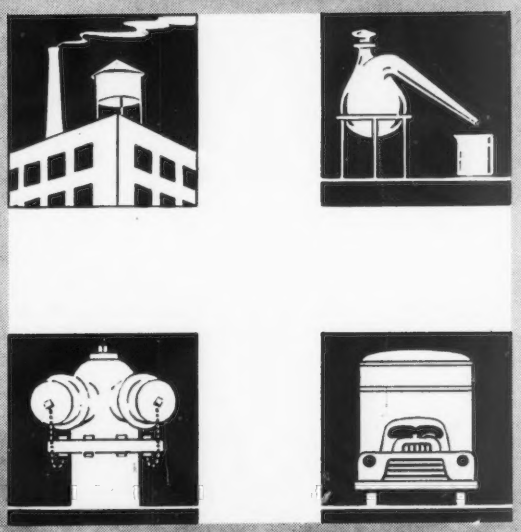

FEBRUARY 1956

Volume 1 Number 1

As this first issue of the Journal section goes to press, all of us here at the Society headquarters are breathing a sigh of relief. The Journal has been a long time in the planning, and we've built up a lot of tension trying to make it as useful as possible. Of course, we hope to continue planning, and changing, to make future issues of the Journal better. We would like to have your comments to help in this process. But we want to point out, too, that this issue contains quite a variety of material that we hope will interest you. Our Society president's message on page one outlines the editorial policy of our new publishing venture, and on page five our managing director has prepared a story on the Society's progress. Page two features an article on grounding of electrical equipment, and on page seven we have a method for making fuel cells safe. Fleet operators will be especially interested in the page thirteen story on accident control in trucking. And we want to call particular attention to Dr. Irving Hartmann's page nine technical report on explosibility of American coals.—The Editor.

AMERICAN SOCIETY OF SAFETY ENGINEERS

Organized 1911 — Chartered 1915

425 North Michigan Avenue • Chicago 11, Illinois

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our president speaks on safety

The publication of this first issue of the Journal of the American Society of Safety Engineers is an important step in the development and growth of the Society. It is a mark of progress of which all members of the Society can be proud.

The Journal will mean a great deal to the Society in terms of the prestige our publication will bring to the Society and its members, and to the safety engineering profession.

But even more important will be the service it can perform for our profession. Through the publication of this Journal, we can give safety engineers and others information that will help them do a better job in the prevention of accidents, inspire others to enter the profession, interest management officials to apply safety engineering more effectively in their business operations, and better enable safety engineers and management to cope with the ever-increasing technical complexity of hazards in the industrial community. The attainment of these purposes will justify the birth of this Journal.

Naturally, all of these aims cannot be implemented by any one issue. Later, as we look back over the total material presented through the years, we expect to see that in all these areas our Journal is making a substantial contribution.

Through technical articles, we will make available to our readers some of the new knowledge in safety which is being developed constantly through research and on-the-job experience. The pages of the Journal will carry discussions of safety philosophy, and present opposing opinions on controversial issues, expressed by men of prominence in safety engineering and other professions, in an effort to stimulate discussion of these issues and encourage the investigation and research through which they may be resolved.

This, then, is the cornerstone upon which this Journal has been founded. With time we hope to see it grow in size, in readership, and in its service to safety and to humanity.

Edward B. Landry

EDWARD B. LANDRY, PRESIDENT
AMERICAN SOCIETY OF SAFETY ENGINEERS

Electrician inspects ground connection in starter of 440 volt portable man cooling fan.

GROUNDING EQUIPMENT IN INDUSTRY

by R. J. Beeswy

EACH year statistics show that personnel in industrial plants are seriously and fatally injured as the direct or indirect result of inadequate grounding of electrical equipment.

American industry is growing rapidly. Must electrical injuries and fatalities due to inadequate grounding keep pace with industrial expansion?

All companies should give this question attention. And every effort should be made to decrease the present number of injuries and deaths from this cause.

At the Inland Steel Company proper grounding of electrical equipment is an important part of the overall safety program, and is the responsibility of the electrical department. Some of the procedures adopted for grounding equipment have proven themselves over the years and are presented in the following paragraphs so that some helpful information might be passed on to promote greater safety to both personnel and equipment in other plants.

Structural Grounding Networks

The main ingredient of a good equipment grounding system is the establishment of an effective grounding network between building structures and the non-current carrying parts of various equipment. Due to the fact that many of Inland's buildings are of metallic construction, lightning, or contact with an accidental grounded unit could create a voltage dangerous to human lives. To accomplish adequate protection a grounding network is established by driving several ground rods and connecting them to building columns with 1,000,000 CM cables. This practice in turn permits suitable grounding of electrical equipment to building frames.

At our new Open Hearth shops a very effective grounding network was established. 1,000,000 CM cables were brazed at 46 different points to building pilings, which were driven to a depth required for a solid footing. The ground cables were then bolted to the pilings and building columns. Where the cables are below grade, they are embedded in concrete for protection. This combination had a resistance to ground of less than one-third ohm.

Brick buildings and stacks are provided with a lightning rod system. This arrangement consists of several rods, known as "air terminals," extending above the height of the structure and interconnected to one or more suitable driven ground rods. Connecting cables between the air terminals and the ground rods are known as "down-comers," and are usually of 4/0 stranded wire. More than one down-comer is installed to insure protection in case one cable may become discontinuous. These

Most grounds are bare copper conductors, left exposed for visual inspection of continuity.

systems are periodically inspected with the aid of binoculars.

Power and Substations

Adequate and permanent ground for power and substations is guaranteed by connecting to the nearest large water main with bare 1,000,000 CM, stranded, copper cable. This cable is circulated through the earth for such a distance as to make it a good ground, even without the water pipe connection. The ground cable is connected to the building frame in several locations, and from this cable is extended a ground bus of one-quarter inch by four inch copper stock for easy connection by all ground cables at switchgear locations.

Ground cables are connected to instrument transformer secondaries, corona shields, switchgear frames and covers, transformer frames, motor and generator bases, lightning arrestors, rheostat frames, switch boxes and other equipment that might be charged electrically in any manner. Grounding corona shields of high voltage requires skill in making the stress cones at the shield termination. The practice at Inland has been to ground the shield at only one end.

Most of the grounding is done with a bare copper conductor, round or flat braid, and is usually left exposed where a visual inspection can determine its continuity. The sizes of grounding conductors are taken from the National Electric Code, which covers this matter very thoroughly.

At the various motor rooms, just as at the substations, a ground system is provided to ground all electrical equipment that is deemed necessary.

Auxiliary Equipment

As in the case in many plants, auxiliary equipment at Inland Steel is operated at many voltages—440 volt, three phase, 25 cycle is one of the more common. Every motor, control cabinet, starter, conduit and controller even though mounted on a metal base or panel, is grounded just as thoroughly as high voltage substation equipment. Where possible, ground connections are made visible so that an easy, quick continuity check can be made periodically. Control circuits for 440 volt equipment are specified to be 110 volt to reduce the hazard to operating people. Sometimes in areas limited to electrical maintenance personnel, 440 volt control is used. Here, however, rubber matting insulates the person who could make contact to ground, while servicing the equipment.

Another voltage used extensively throughout the plant is 250 volt D. C. Numerous 250 volt sources of power, each supplying its own system, are located throughout the plant. These systems are not grounded intentionally, but occasionally grounds, resulting from insulation failures, do exist. A continuing check is made of equipment to eliminate these unintentional grounds. This is necessary because a ground in the control circuit can unexpectedly start a machine. As a further protection, both sides of the line are sometimes interrupted with the controller instead of the conventional one side. This is done for example on blast furnace skip hoist control circuits.

Ground detectors in the form of indicating lights or meters are used on all systems. Better insulations, proper installations and good maintenance have reduced the number of grounds considerably over past years.

Portable and Office Equipment

When operated from a 250 volt D. C. source, portable equipment is provided with a ground wire attached to the building frame or some other suitable ground. Periodically, a qualified electrician inspects the equipment for a possible insulation failure. Portable tools operating at 110 volts are not grounded unless employed in a hazardous atmosphere or location. Movable man-cooling fans which are operated on 440 volt, three phase systems have been one of the biggest problems in maintaining suitable ground connections. These fans, consisting of a 3 H. P. motor mounted on a vertical stand, which is sometimes mounted on wheels for easy movement, weigh about 200 pounds. The fans are moved about at the disposal of operating personnel to places where they are desired. Because the flexible electrical cables are exposed to weather, heat, moisture and severance by human actions, a suitable exposed ground wire is hard to maintain. A braid was twisted around the three conductor cable, but sooner or later several feet of it was missing to be used as a radio antennae, or some other purpose. Flat linked chains were tried as an external ground, but when the tension was taken off they no longer made good continuity due to the separation of the links. A No. 12 wire, four conductor, cotton braided cable with rubber insulated leads surrounded by a .010 inch tinned copper braid has been adopted as standard. The one No. 12 wire to be used as a ground is marked with a white braid. The ground conductor and copper braid are connected to a metal part of the man-cooling fan and at the switch to a grounded terminal provided for it.

Most office equipment, such as typewriters and computing machines, are grounded whenever they are operated near a radiator, water pipe or other grounding

R. J. Beeswy heads the Electrical Department, Indiana Harbor Works, Inland Steel, where he has been in electrical work for 38 years. His article is based on a paper he presented at the 1953 National Safety Congress.

medium with which the operator might come in contact. Other equipment, such as water coolers and air conditioning units, always have the frames grounded.

With the 250 volt D. C. office equipment as well as some of the newer 110 volt systems for office service outlets, a three prong, polarized plug is employed with the third wire used to ground the frame. Special sockets and plugs have been adopted for all low voltage service outlets to prevent injury which could occur due to plugging into a higher voltage than that for which the apparatus or appliance was designed. Also, as an added safety measure, the outlets are stenciled so that a visual check can determine the voltage.

Lighting

Practically all plant lighting is 230 volts A. C. or D. C. Switches, transformers and all metal housing for electrical equipment are grounded. Office lighting is primarily 208/120 volts, 25 cycle, and operates with the grounded neutral. Some office lighting is being converted to 110 volt, 60 cycle, fluorescent fixtures. This 60 cycle system operates with a grounded neutral similar to home installations, unless fed from a small isolated motor-generator set, which may or may not have one line grounded.

Also, throughout the plant a special form of low voltage lighting is provided for personnel working inside or near metal enclosures, in vaporous atmospheres, or in areas where it is necessary to stand in water. Portable transformers supply 12 volts for as many as five 50 watt lamps. These 250 watt transformers are supplied from a 230 volt, 25 cycle source. All plugs and sockets for the 230 volt and 12 volt connections are of a selected type so that plugging into a higher voltage is not possible.

Hazardous Locations

Special care is taken to prevent explosions due to dynamic or static voltages in areas where explosive atmospheres exist due to flammable liquids. In the coke plant's benzol and naphthalene buildings and yards, 32 two-inch pipes are jetted into the earth to a depth of 20 feet. Inside of each is placed a three-quarter inch pipe containing a 4/0 trolley wire. The excess space is filled with coke breeze and periodically wet down to maintain a good ground. The 32 ground connections are joined together to form a network, and then ground wires are tapped onto this system.

Periodically, these ground rods are checked by measurements to prove their effectiveness. One at a time, a lead going to one ground rod is removed and the resistance between it and the remaining ground network is measured. If a discrepancy is noted, repairs are made or a new rod is driven to replace the old one.

All tanks, pipes, metallic insulation mesh for tanks and pipes, motors, switches, conduit, fixtures, metal frames and supports are grounded. No metal banding of pipes is allowed, and no metallic paints are used due to the capacitive effect created. Benzol plant railroad tracks are insulated from the rest of the plant system, and are bonded and grounded. All pipe flanges have copper shunts around them. Electrical equipment is of the explosion or vaporproof type, but is being rapidly converted to all explosion proof equipment. Only non-sparking repair tools are used, and these are equipped with static proof parts. Also special Bureau of Mines approved flashlights are provided in an effort to eliminate every possible spark which could cause an explosion.

Electrostatic Grounding

Electrostatic charges developed due to rotating, rolling, or sliding equipment can sometimes be dangerous and destructive, as well as a nuisance. Care is taken to provide ground connections on metal frames of large rotating, non-electrical equipment, such as pumps and blowers. Static charges on conveying belts are removed by grounded metallic idler rolls or grounded contact brushes, where required. This is especially true in explosive atmospheres.

In dealing with high voltage precipitator equipment for cleaning blast furnace gas or removing coke plant tar residue for by-product purposes, special attention is given to grounding all adjacent metallic parts. The 75,000 volt equipment is enclosed, and electrical interlocking is provided to prevent entrance without first shutting down the high voltage rectifiers. Also to obtain entrance to the rectifier units, the necessary key can be obtained only by first shutting down the rectifier. The key is so placed as to make this mandatory. As an additional safety measure, a grounded probing cable or chain with an insulated handle is provided to discharge any cumulated electrostatic charge on the high voltage equipment, before attempting to service it. As on the high voltage precipitator equipment, electrical interlocking is provided on X-ray machines in both mills and plant hospitals. This interlocking and the fact that only qualified technicians may gain entrance by key eliminate high voltage and radiation hazards.

Maintenance

Periodically, ground rods are checked to insure that grounding networks are of minimum resistance. A portable ground resistance meter is employed to determine the resistance. The meter has a movement which measures the drop in potential between the measured ground rod and a test ground rod, and the current created by the instrument, which flows through the measured rod and a second test rod. By using two test rods, the measurements are independent of the ground resistance of these rods. The effects of stray currents are also eliminated by designed features of the meter.

Grounding wires from equipment to the networks are installed for ease of observation by electrical maintenance personnel. When a loose connection or a broken wire is discovered, repairs are affected immediately.

Training of Personnel

To insure that maintenance personnel are vigilant to locate faulty grounding connections, the why's, where's and how's of adequate grounding are periodically reviewed during training sessions and safety meetings. Demonstration devices have been constructed to visually show the consequence of inadequate grounding. It is hoped that on-the-job training will be utilized by personnel not only at the plant, but at their outside activities to curb electrical injuries and fatalities in the home.

STATE OF NEW YORK

Office of the Secretary of State

ALBANY

It is hereby Certified, that

THE Certificate of Incorporation OF

"American Society of Safety Engineers, Inc."

with acknowledgment thereto annexed, was filed and recorded in this office on the twenty-seventh day of March, 1915.

Witness my hand and the seal of office of the Secretary of State, at the City of Albany, this 24th day of May, 1915.

Francis M. Hugo Secretary of State

AMERICAN SOCIETY OF SAFETY ENGINEERS: MILESTONES

by J. B. Johnson, Managing Director of the Society

THE history of industrial development in America is a thrilling story of many chapters, not the least of which are those dramatic pages contributed by the safety movement.

Safety has had, and still has, its struggles against inertia and ignorance. It continues to adventure in research, finding new and safer methods and machines. And what greater drama could there be than the devotion of man to man that has been the inspiration and strength of the safety movement.

Many great organizations and many great men have earned prominent places in the annals of safety. Members of the American Society of Safety Engineers can be proud that their Society is one which has been an integral part of this exciting movement.

Today, the Society is stronger and more active than ever before in its history. Its membership of more than 6,500 is spread throughout the world, with 61 chapters in the United States, Canada and Hawaii.

There are other evidences of expansion, too, such as the Society's publication for members, Engineering for Safety, which has grown from a one sheet mimeographed letter to a printed monthly news magazine. The most recent milestone in the Society's progress is this first issue of our Journal.

The Society indeed has come a long way since its beginning in October, 1911, when 35 men got together in New York City to form the United Association of Casualty Inspectors with the avowed objective "to promote the social and educational advancement of its members in the prevention of industrial accidents."

Only a few years previously workmen's compensation legislation had first been proposed in America. In the words of the late A. D. Caddell, former managing director of the Society, it was a time when "mounting public opinion demanded action to control the needless waste caused by industrial accidents. The magnitude of the problem, even at the then comparatively low industrial levels, indicated the need for exchange of thought and experience, to cope with the increasing totals of injuries."

Apparently the new organization helped to meet this need, for it grew and prospered. In May, 1914, a name more descriptive of the objectives of the group was adopted—the American Society of Safety Engineers. The first meeting under this new name was held in New York City on December 6, 1914, and in 1915 the Society was incorporated in New York State as a corporation not-for-profit. The original charter, which is reproduced at the beginning of this article, has been in force continuously since 1915.

There was duplication in the efforts of the Society and the National Safety Council and in 1924, after long consideration, the Society became an organic part of the Council as the American Society of Safety Engineers—

AMERICAN SOCIETY OF SAFETY ENGINEERS

PAST PRESIDENTS and CHAIRMEN

1911	J. E. Anderson	1933	S. E. Whiting
1912	J. G. Shaw	1934	A. S. Regula
1913	A. A. Frazee	1935	C. W. Smith
1914	E. D. Haggerty	1936	D. L. Royer
1915	W. E. Welch	1937	C. B. Boulet
1916	H. H. Dehn	1938	R. E. Donovan
1917	C. Van Horn	1939	F. W. Braun
1918	C. Van Horn	1940	F. W. Braun
1919	H. W. Mowery	1941	H. J. Griffith
1920	H. W. Mowery	1942	Wills Maclachlan
1921	G. E. Sanford	1943	H. R. Bixler
1922	C. O. Smith	1944	W. D. Keefer
1923	W. J. Venning	1945	W. D. Keefer
1924	A. J. Van Brunt	1946	R. M. Godwin
1924	A. D. Risteen	1947	J. S. Shaw
1925	G. E. Sanford	1948	R. H. Ferguson
1926	E. W. Beck	1949	E. C. McFadden
1927	R. McA. Keown	1950	W. P. Yant
1928	J. I. Banash	1951	J. C. Stennett
1929	C. B. Auel	1952	C. H. Weiser
1930	R. F. Thalner	1953	W. F. Brown
1931	M. G. Lloyd	1954	W. N. Cox Jr.
1932	H. S. Smith		

HONORARY MEMBERS

1946	John Roach	1953	John J. V. Forbes
1947	Daniel Harrington	1953	John Stilwell
1948	Ned H. Dearborn	1954	Clarance H. Weiser
1953	James I. Banash	1954	Sidney J. Williams
1953	W. H. Cameron Sr.	1954	William P. Yant

Engineering Section, National Safety Council.

The relationship as the Engineering Section of the National Safety Council was maintained for 23 years, until October 7, 1947, at which time the membership of the Society voted to reestablish the Society as an independent organization.

Just what is the Society today? Perhaps the best answer can be found in its stated objectives and in some of the activities with which it implements them. The Constitution of the Society now contains a broader statement of objectives than was conceived in 1911. Originally concerned only with the social contact and educational advancement of its own members, the Society has since expanded its concept to make available to everyone the engineering principles developed within the group.

As set forth in the Constitution, the objectives of the Society are

(1) to promote the arts and sciences connected with engineering in its relation to accident prevention and the conservation of life and property;

(2) to attain a high standard in safety engineering;

(3) to encourage the development of safety engineering as a profession.

Of course the measure of any organization such as the American Society of Safety Engineers must be taken, in the final analysis, in the light of specific activities which bear out the high-minded aims expressed. And in this respect the Society has not fallen short.

To cover fully only one activity from the Society's history of service to the safety engineering profession—the development of technical data for the solution of engineering and other problems—would require more space than can be devoted to this entire article. The Society, through its Committee on Technical Publications, has long cooperated closely with the National Safety Council in the preparation of Safe Practices Pamphlets and Industrial Data Sheets. And this work continues today as Industrial Data Sheets constantly are written and reviewed by the Society.

Another recent activity has been the publication of a revised edition of the outline, "Industrial Safety for Engineering Students—A Suggested Engineering College Course." The course, a project of the Committee on Cooperation with Engineering Colleges, is designed to help bring a sound understanding of basic safety principles to all engineers.

The Society's Committee on Safety Standards has worked closely with the American Standards Association in seeing that the Society is represented on every important AAA Safety Code Committee.

To mention only the names of a few other Society committees will give an idea of the scope of this virile program for safety—the Committee on Cooperation with Engineering Societies, which carries on liaison in accident prevention activities; the Committee on General Publications, which aids in presenting current news and technical developments to the membership; the Committee on Improved Membership Services, which initiates material to meet the needs of Society members for assistance from the national level; the Committee on Membership, which safeguards membership standards; the Committee on Chapters, which evaluates chapter performance; the Committee on Public Relations, which increases the prestige and usefulness of the safety engineer and the Society through promotional projects; the Committee on Research, which seeks out and helps direct needed studies to add to the fund of safety knowledge; the Committee on Safety Laws and Regulations, which keeps the membership informed of pending and newly passed legislation of interest to safety engineers; the Committee on the Study of Traffic Safety, which keeps abreast of developments and assists recognized traffic groups in the solution of problems in this vital field of safety; the Committee on Finance, which maintains our sound fiscal policy.

And no list of Society committees can be completed without a mention of the Committee on Awards and Honors, which guides the Society's Albert D. Caddell Chapter Achievement Award Program. The awards—one grand award and five regional awards—are presented annually to chapters which lead in activities of benefit to the Society, the profession and the community.

Through reports submitted for this awards program can be seen the tremendous volume and variety of activity that chapters of the Society undertake in the collection and dissemination of technical material and in participation in civic service projects such as school plant inspections, junior achievement, traffic safety programs, scholarship awards, consultation service for small industries, educational radio and television broadcasts.

This, then, is a brief picture of the American Society of Safety Engineers—its history, aims and accomplishments. The publication of this Journal is another milestone in the history of an organization which will continue to advance in serving humanity as a contributing partner in America's safety movement.

Air Held Superior To Inert Gas in Creating Gasoline-Free Atmosphere

by Fred R. Temple

MAKING it safe for men to work inside and around the largest airplane gasoline tanks in the world is one of the most important jobs of safety engineers at the Fort Worth plant of Convair Division of General Dynamics Corporation.

Shortly after Convair began building the record-breaking 10-engine B-36 bombers, it became evident that procedures would be needed for servicing and maintaining them. Work on the fuel cells (inside the 230-foot wing) would be the most dangerous of all—especially so since the aircraft uses only the highest octane military-type gasoline.

When an airplane required work, our problem was this: to empty the fuel cells and dry them out to give us a safe, gasoline-free atmosphere. This was necessary because employes (two or more per tank) had to work inside the tank to find and make the needed repairs. An employe in a tank containing a flammable atmosphere posed a constant hazard both to the employe, the aircraft, and other employes in the vicinity of the dangerous tank.

Much of the work was of very tedious nature involving (1) finger dexterity, (2) use of small hand tools, and (3) good eyesight. So it was not advisable to burden the employe with bulky protective equipment. We also thought the employe himself would not like these working conditions. So we set out to develop a purging (gas free) procedure to make the tank safe and to maintain the best practical working conditions.

To begin with, we considered the various known methods of treating such a problem, and evaluated the advantages and disadvantages of each.

Using an inert gas such as carbon dioxide would give us (1) a cooling effect and create moisture inside fuel tanks, and (2) pose a hazard from static electrical charges in the usual methods of injection. Argon or nitrogen in the tank atmosphere would involve the same handling of bottled gases, as well as the expense of maintaining the inert atmosphere. Since the tank had to be dried out, the injection of inert gases seemed not to assist in solving the problem but would merely add another step to the operations necessary in the process.

In short, we concluded that we should use the thing which nature provided most freely: air.

The next question was whether to (1) inject the air into the atmosphere, or (2) by suction pull the atmosphere out of the tank and allow it to be replaced by non-hazardous air. To use air blowing into the tank would force hazardous atmosphere of the tank through various openings. There again the problem of creating static charges on the turbulent vapor clouds inside the tank would be very hazardous and a source of explosion.

Thus, by elimination, evacuation of the tank atmosphere by *low* velocity, *high volume* exhausting seemed the safe answer. It had the advantages of (1) no inherent hazards, (2) a slight vacuum condition (reduced atmospheric pressure) which would accelerate air and a controlled outlet for the dangerous fuel vapor.

Through exhaust fans or blowers, this atmosphere (1) could be moved and discharged at virtually any safe point desired, (2) allowed us to use flash screens to prevent back flashes to the tank, (3) eliminated use of additional costly equipment, and (4) made possible the use of portable equipment for the job to avoid moving the airplane.

Our next problem was (1) determine the equipment, and (2) develop the procedure. In the initial stages, very simple, commercially available equipment in the form of a six-inch air mover attached to a one-inch 100-pound airline was used. This equipment proved satisfactory but was later replaced by specially designed equipment as shown in the photograph.

Our next problem involved drawing up the procedure. This procedure finally evolved:

1. Ground the airplane.
2. Bond the fuel draining equipment to the airplane and ground it to a common point with the airplane.
3. Drain the fuel tank by pump or gravity flow.
4. Pick up by vacuum pump the residual fuel which in shop terms is referred to as "depuddling."
5. Attach the vacuum air mover or blower equipment by first bonding it to the aircraft then attaching it to the tank opening (access door) in the spar.
6. Remove the fuel tank cap, assure the vent line is open, and drain and remove the booster pump.
7. Start the exhaust or vacuum which pulls air through the tank to dilute the fuel vapors and dry the tank.

This process is continued for the necessary period of time until the tank atmosphere, when left undisturbed for 30 minutes (exhaust stopped), shows by explosimeter test that it contains less than 15 per cent of the lower explosive limit of fuel vapor. When this point is reached equipment is removed, employes are allowed to enter the tanks and perform their work.

Normally some type of ventilation is utilized for the comfort of the workers during repair. Of course, during the work around the fueled aircraft, standard safety procedures in control of body static, grounding and bonding, explosive-proof lights and use of air tools are employed.

This equipment and procedure was used on hundreds

Fred Temple is supervisor of the Safety Engineering Section at Convair, a division of General Dynamics Corporation, Fort Worth, Tex. He is a member of the Society, and past general chairman of the Fort Worth Chapter.

of fuel tanks until the early part of 1951 when an employe placed a one-inch airline inside a fuel tank. Within seconds after the air pressure was turned on, the tank exploded. The explosion was probably set off by static changes from the high-pressure moisture-filled 100-pound air stream. At this time it was decided that special equipment would be designed and additional controls and safeguards be used for the gas freeing (purging) process.

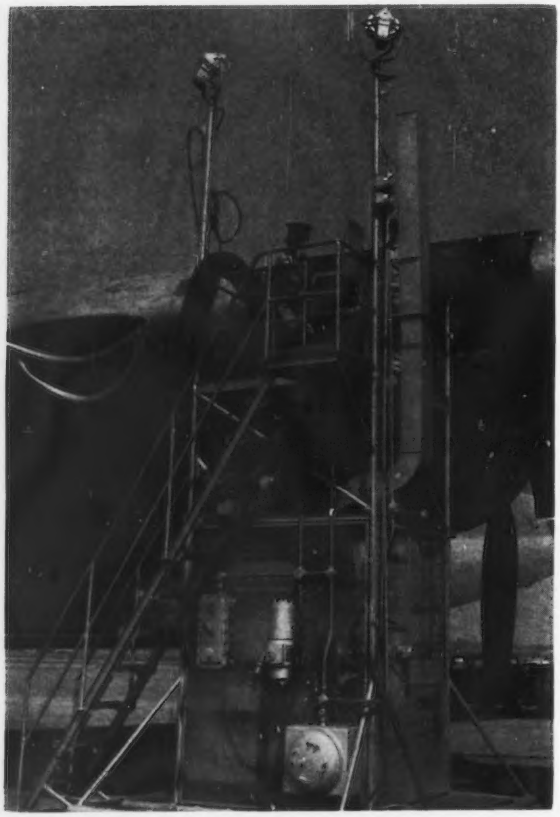
At the direction of management, the Safety Engineering Section led a group in setting up improved procedures, new equipment, isolation of the operation and the designating of a special crew adequately trained in safe procedures.

Valuable assistance and contributions were given by Convair plant engineering, electronics, engineering, industrial security, and industrial engineering people. The procedure was left virtually intact as previously set up. The group thinking was unanimous in that specially designed equipment with an adequately trained crew, briefed by the safety engineering group, was necessary to prevent possible recurrence of the explosion mentioned above.

It was also agreed that no other work which would pose possible source of ignition would be done during the gas freeing or fuel handling operations. Later a special station was allocated for this hazardous type of work.

The special equipment designed was a portable stand with a 2500 CFM exhaust fan equipped with an eight-inch flexible duct, explosion-proof electrical equipment and circuits; all electrically bonded and with provisions for grounding and bonding to the airplane. One such stand was provided for each of the six wing tanks of the B-36.

Purging stand in use for fuel tank of B-36 at Convair. Man on platform is checking for gas-free atmosphere.



This equipment is adaptable and is being used for other types of aircraft, i.e., C-54. The exhaust duct is an electrically bonded metal duct equipped with a flash screen at the outlet which is high above the airplane and other possible sources of ignition. We have found that with the 2500 CFM blower on the largest B-36 fuel tanks, after some 5 to 12 minutes of suction, the atmosphere is diluted below the lower explosive limit and from then on the tank is perfectly safe until it is adequately dried out.

At one time the use of inert gas for injection prior to gas freeing a fuel tank was proposed. In the performance of an engineering test utilizing low pressure nitrogen for inerting, we found that the safest procedure was to start with a full fuel tank, replacing the fuel with nitrogen as the tank was drained. This involved (1) filling a partially full fuel tank, (2) additional equipment for the inerting with nitrogen in the exhaust process. In the exhaust process, the residual vapors from pockets of liquid fuel and the drying out of sealants was sufficient to change the tank atmosphere to slightly above the lower explosive limit in spite of the inerting gas. Probably this was occasioned by capacity of the exhausting fans being much greater than the volume of the injected nitrogen. The reduced flow of nitrogen gas to eliminate static charges limited the volume of the gas going into the tank. The complete process increased the elapsed time (hurting production schedules) necessary to gas free fuel tanks. After two such engineering tests, injection of inert gas was abandoned.

One of our basic principles in the handling of flammables is to keep the elapsed time at a minimum, as well as to eliminate all possible sources of ignition.

In this operation, we accept as almost inevitable the fact that two of the three legs of the fire triangle are ever present: (1) fuel vapors in a flammable range, and (2) sufficient oxygen to support burning. Thus eliminating the ignition sources (heat) becomes all important. And when elapsed time (exposure) is reduced, we reduce the chance of fires and explosion.

We have had one mishap in the gas free process of purging thousands of fuel tanks. The error in this mishap is pretty obvious, and should never have been done by our employe—nor anyone else. Our policy calls for gas freeing fuel tanks on all of B-36 aircraft going through our maintenance program, as well as other aircraft where shop operations involve the fuel tanks or require the use of conventional aircraft manufacturing equipment. This gas freeing (commonly called purging) of the fuel tanks allows us to perform safely many work operations with conventional tools, open type electrical equipment and in locations that would not otherwise be safe.

A hazardous fuel tank atmosphere would require much costly personal protective equipment, electrical equipment, and/or air tools not needed around the *safe* fuel tanks.

There is also another important value which we are not able to measure in time or money: the feeling of our employes that the company is making every effort to provide a safe place in which to work.

Explosibility of American Coals

Physicist Irving Hartmann is chief, Branch of Dust Explosions, Division of Explosives Technology, U. S. Bureau of Mines, Pittsburgh, Pa. This article is based on Bureau of Mines Report of Investigations Number 5052.

by Irving Hartmann, Ph.D.

THIS investigation was undertaken to obtain data on explosive characteristics of several ranks of coals. Need for this information arose as a result of current applications of pulverized coals in industry. These include pulverized-coal boilers, fluidized fuels, turbines for railroad locomotives, coal gasification, chars of low-rank coals, activated carbons, foundry facings, jet propulsion, synthetic liquid fuels, plastics, chemicals, etc. In some instances the coal dust is normally in suspension in air, in oxygen, in oxygen-deficient, in oxygen-rich, or in other special atmospheres; in other applications the dust is dormant, and no explosion hazard exists unless it is dispersed and ignited.

The coals were taken from seams in different parts of the country, ranging from lignite to meta-anthracite. Most studies were made on coal dusts which passed through a 200-mesh sieve (74-micron-square). Some experiments were conducted with so-called mine-size dusts, in which all particles were finer than 20-mesh (Tyler sieve scale), and 20 per cent by weight passed through a 200-mesh sieve.

In tests on the effects of particle size, samples composed of definite sieve fractions were used, that is, 48- to 65-, 65- to 100-, 100- to 150-, 150- to 200-, 200- to 270-, 270- to 325-, and through 325-mesh. In another set of experiments the effect of varying proportions of through-200-mesh particles in the samples was studied; the fine dust was added to coarse aggregates consisting of particles between 20- and 200-mesh.

To evaluate the effect of moisture on the explosibility of coal dust, experiments were made with bituminous Pittsburgh coal, to which various percentages of water had been added, and with a subbituminous coal (with an initial moisture of 11 per cent) that had been gradually dried so that it retained different amounts of moisture.

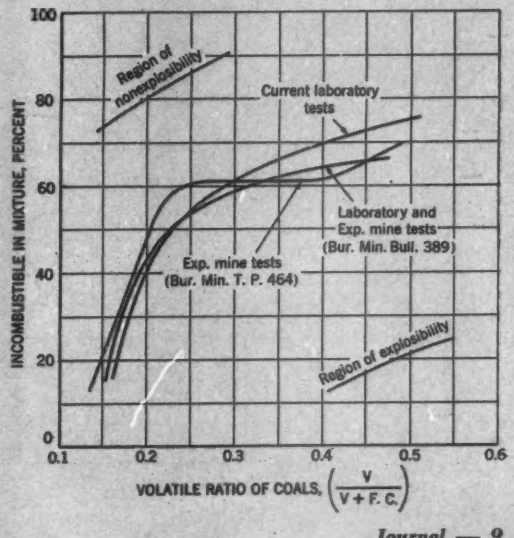
The test data represent relative rather than absolute values, since results depend to some degree on the size, shape, and other characteristics of the explosion vessels; uniformity of the dust clouds; exact particle-size distribution; intensity, size and duration of the ignition source, and other variables.

Most experiments were performed in air, but in many tests the dust was dispersed and ignited in oxygen. To determine the limiting percentage of oxygen that will support combustion, in a few tests mixtures of air and CO_2 were used; for Pittsburgh coal the limits were evaluated at different ambient temperatures.

Figure 1 shows the incombustible or rock-dust requirements for preventing flame propagation in dust clouds of various ranks of coals. The curve, based on current laboratory tests, on the whole indicates good correlation with results of earlier experiments on other samples in the laboratory and in the experimental coal mine. As can be seen, the incombustible requirement is less than 50 per cent for coal dusts of volatile ratios below 0.20, and the value becomes 65 per cent or more only at volatile ratios of about 0.30 to 0.35.

Figure 2 shows the effect of volatile content on the lower explosive limit, minimum igniting energy, and ignition temperatures of coal dusts. In air it was most difficult to ignite dust clouds of low-volatile bituminous coals and anthracite by electric sparks, and therefore their lower limits and minimum energies could not be determined; in oxygen, ignitions were readily obtained with all coal dusts. The curves show that the ignition sensitivity increases and the lower explosive limit decreases with increased volatile content. In oxygen this

Figure 1 — Explosibility of mine-size coal dusts, based on tests in the experimental coal mine and in the laboratory.



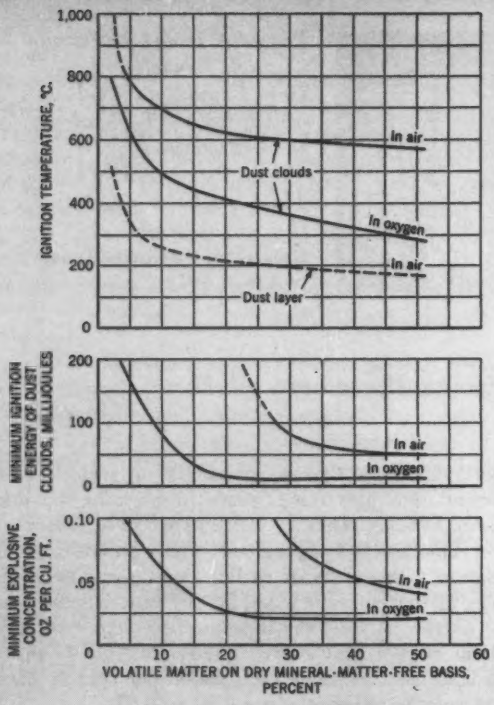


Figure 2 — Minimum explosive concentration, minimum igniting energy and temperature of through-200-mesh coal dusts in air and in oxygen.

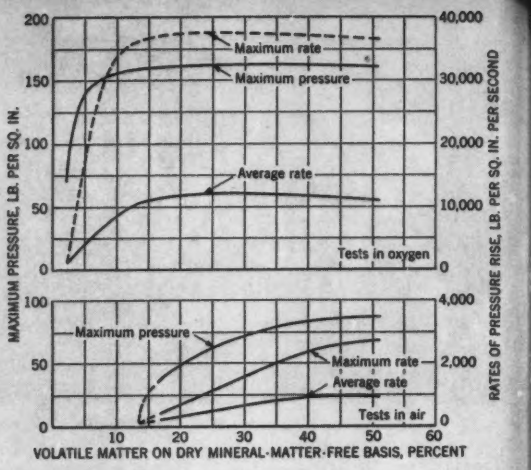
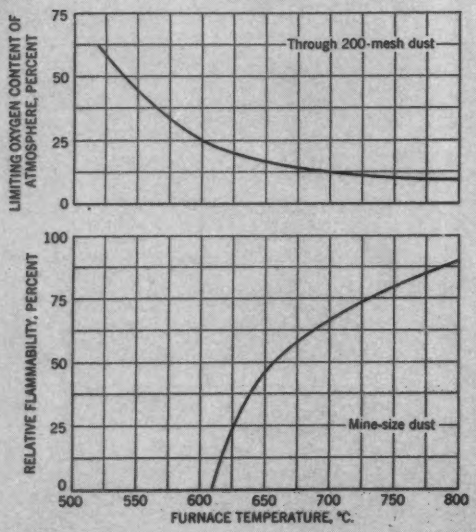


Figure 3 — Maximum pressures and rates of pressure rise developed by explosions of 200-mesh dusts in air and in oxygen (dust concentration = 0.50 oz./cu. ft.).

Figure 4 — Relation of temperature to relative flammability and to limiting oxygen content in atmosphere for preventing ignition of dust clouds of bituminous Pittsburgh coal.



effect becomes less important above a volatile content of about 20 per cent.

Figure 3 shows the effect of volatile content on the maximum pressures and rates of pressure rise developed by explosions of dust clouds in a closed bomb; rates above 15,000-20,000 lb. per square inch per second are approximations. The curves show that in air the pressure and speed of the explosions increase with increase in volatile matter, whereas in oxygen there is little change in intensity above 20 per cent volatile. This figure, as well as others, shows that the hazard of coal-dust ignitions and explosions in oxygen is several times as great as in air.

The maximum pressures and rates in the air tests were attained at (optimum) concentrations of 0.50 to 1.00 ounce per cubic foot, which is several times the stoichiometric composition. Explosion tests in oxygen could not be performed at concentrations above 1.00 ounce per cubic foot, the limit being set by the strength of the test equipment. None of the dusts tested attained peak pressures below this concentration.

The effect of initial pressure on explosions was studied with one bituminous coal dust. Pressure tests were made at concentrations ranging from 0.10 to 2.00 ounces per cubic foot (approximately 0.10 to 2.00 gm. per liter). It was found that, in all cases, the maximum explosion pressures and the rates of pressure rise increased linearly with the initial pressure. As an example, at initial pressures of 0, 10, and 20 p.s.i.g., the explosion pressures were determined to be 73, 99, and 125 p.s.i.; the average rates were 2,100, 2,700 and 3,350 p.s.i. per second; and the maximum rates were 4,300, 5,700, and 7,100 p.s.i. per second.

Increase in particle size reduces ignition sensitivity and pressure developed by explosions. Dust clouds of fractions of Pittsburgh bituminous coal coarser than 150- to 200-mesh could not be ignited in air by electric sparks.

In oxygen, on the other hand, ignitions and (mild) explosions were produced, even in dispersions of 28- to 35-mesh particles; the effect of particle-size increase is much less pronounced than in air.

The ignition temperature of dust clouds of Pittsburgh bituminous coal is fairly constant as the particle size increases to about 180 microns (65- to 100-mesh), being about 200° C. lower in oxygen (425° C.) than in air (610° C.); further increase in size results in rapid rise in the ignition temperature. The relative flammability, determined at a furnace temperature of about 700° C., decreases with increase in size of dust particles, as might be expected.

Addition of fine (through 200-mesh) dust particles, up to 30 to 40 per cent of the total (by weight) results in a very significant reduction in the minimum explosive concentration and the minimum igniting energy, and further increase has much lesser effect. The relative flammability of dust clouds increases almost linearly with increase in the proportion of fine particles.

The effect of moisture on explosibility of coal dust is important in some industrial processes and also under special mining conditions, with relation to rock-dust requirements. For fine Pittsburgh coal dust, there is little change in the lower explosive limit up to about 8 per cent moisture, but beyond that the required dust concentration increases sharply. The minimum igniting energy is 50-60 millijoules up to 4-5 per cent moisture and then increases rapidly. Data were also obtained on explosion pressures and rates of pressure rise of these samples. At several dust concentrations there appeared to be an increase in pressures and rates with increase in moisture content to 5 per cent and beyond that a fairly rapid decrease in the values. When similar tests were made with a subbituminous coal, dried to various percentages of moisture content, there was very little change in pressures and rates in the range of zero to about 8 per cent moisture content.

The effect of ambient temperature on dust explosibility is important in some industries. Figure 4 illustrates the relation of temperature in the laboratory furnace to the relative flammability of mine-size Pittsburgh coal dust and to the permissible oxygen content in the atmosphere for through-200-mesh dust. The latter curve also gives the ignition temperatures of dust clouds in air-carbon dioxide mixtures with indicated oxygen contents. The hazard of high temperatures is evident from this figure.

The oxygen limits for preventing ignition of dispersions of through-200-mesh dusts were determined for six samples in the presence of an electrical induction spark and in the furnace at 850° C. The samples included one semianthracite, one low-volatile coal, one medium-volatile coal, two high-volatile coals, and one lignite. The following results were obtained:

Sample No.	Coal	Limiting oxygen content, per cent	
		Spark test	Furnace test
1761	Semianthracite	(1)	11.5
1736	Low-volatile	(1)	10.5
1738	Medium-volatile	18.5	10.5
1740	High-volatile A	17.0	10.5
1746	High-volatile C	15.0	10.5
1763	Lignite	15.0	7.5

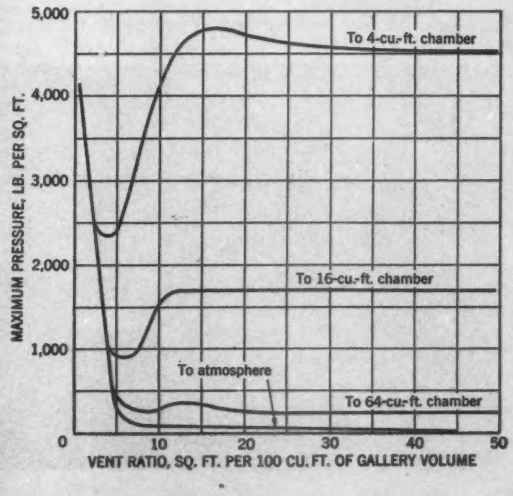
(1) Dust clouds could not be ignited by electric sparks in air.

In industry much reliance is placed on pressure-release vents in equipment and buildings for reducing damage from accidental explosions. Among the important requisites of effective vents, in addition to sufficient area, proper location, etc., is that they open rapidly to permit efflux of the combustion products during the initial stage of an explosion. Normally the vents open directly to the outside or are connected with the outside by short ducts. In such instances the maximum pressure is directly related to the area of the vent opening (frequently expressed as a ratio of the area to the volume of the enclosure). Occasionally, however, the explosion products cannot be released to an unlimited outside volume but must be led to an adjoining larger volume of limited size. Figure 5 contains several curves that show the relation of vent size (between a small explosion gallery and the adjoining larger chamber) to the maximum pressures developed by explosions of bituminous coal dust.

As can be seen, during venting to the outside atmosphere the pressure decreased rapidly as the vent ratio increased to about five and then, having reached a very low value, decreased very slowly. Venting to finite chambers, on the other hand, gave different results, the degree of variation depending on the volume of the chamber. Here an initial increase in vent ratio to 4-8 resulted in decrease in pressure, but further increase in vent size brought about a rise (sometimes quite considerable) in the maximum pressure, followed by a range of constant pressure. The odd pattern of these curves is explained by the ejection of quantities of unburned dust from the 1-cu. ft. gallery and the development of secondary explosions in the larger chambers.

In the course of venting tests in a 64- and a 216-cu. ft. explosion gallery, attempts were made to quench the

Figure 5 — Venting coal dust explosions from one cu. ft. gallery to atmosphere and to cubical chambers of various sizes (dust concentration = 0.60 oz./cu. ft.).



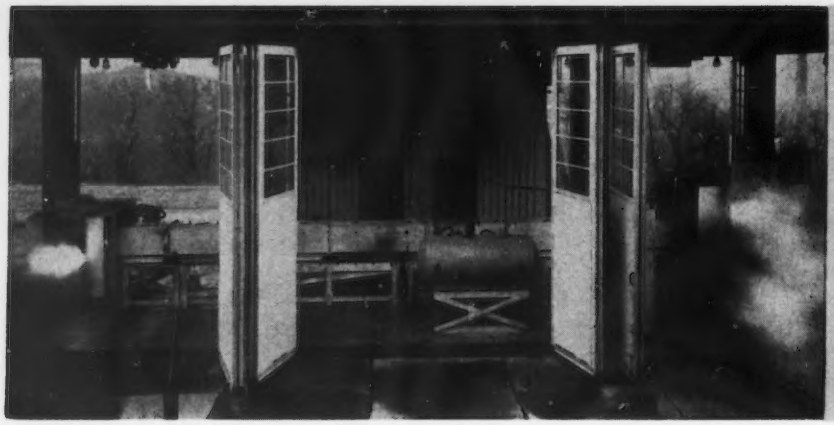


Figure 6—Shown at left are primary and secondary coal dust explosions.

explosion flames during their incipient stages. With coal-dust explosions this was successfully done by dispersing water and limestone from a few polyethylene bags suspended at several points in the galleries. Dispersion was accomplished by electric detonators within each bag; the detonators were fired upon closure of an electric circuit, actuated by a sensitive pressure-pickup in the gallery.

In industrial explosions (and occasionally in mine explosions) frequently most damage is caused, not by the initial ignition, but by delayed secondary and even tertiary explosions, which generally involve greater quantities of dust and larger areas than the first explosion. Some studies have been made on the formation and prevention of secondary explosions. An explosion is started in the 64-cu. ft. gallery, from whence the pressure wave and flame travel through a 32-foot duct to the 216-cu. ft. gallery, in which dust had been placed on a shelf; in many experiments dust was also distributed on the floor of the duct. When no attempts are made to stop the explosion in the duct, usually stronger explosions are produced in the larger gallery. With bituminous-coal dust and with various other dusts it has been possible to prevent secondary explosions (see fig. 6 and 7) by placing vents in the duct, by dispersing water, limestone, salt, or other quenching mediums in the duct from V-shaped troughs, from polyethylene bags, and by water sprays. The troughs were tipped by the pressure waves preceding the flame. In other tests the quenching agents were dispersed by detonators or quick-acting magnetic valves, following closure of electric circuits by pressure pickup devices.

In summary, the present investigation of American coal dusts ranging from lignite to meta-anthracite indicates that (a) the ignition sensitivity and the explosion hazard of coal dusts generally increases with increase in volatile ratio, but not in direct linear relationship; (b) the hazard of coal-dust explosions in an oxygen atmosphere is several times as great as in air; (c) explosibility increases with reduction in particle size—addition of 10 to 40 per cent through-200-mesh coal dust to coarser aggregates has an important effect on ignition sensitivity; (d) the effect of moisture on coal dust explosibility is unimportant below about 10 per cent; (e) increase in initial pressure and surrounding temperature increases the explosion hazard; (f) release of explosions to adjoining larger spaces of limited volume presents special problems and might result in strong explosions in the larger enclosure; (g) some dust explosions can be quenched successfully during their initial stage, and secondary explosions can be prevented by prompt dispersal of quenching agents.

Figure 7—Secondary explosion prevented by water spray in connecting duct.

Regularly scheduled maintenance is a very important factor in fleet safety and economy.

ACCIDENT CONTROL IN

TRUCKING OPERATIONS

by John D. Gallagher

SAFETY in truck operations often is regarded as something separate and apart from operating efficiency, but experience shows that there actually is a close relationship between efficiency of operation and control. The integration of accident control measures into everyday operating practices not only improves the accident experience, but also improves operating efficiency, and thereby increases the profit margin of the operation.

To keep both accidents and operating problems at a minimum, seven basic control factors must receive attention. They are:

1. Proper selection of vehicles for the transportation job to be done.
2. Proper scheduling of vehicles for safe and efficient operation.
3. Careful attention to routing.
4. Correct periodic maintenance, preferably according to a scheduled plan.
5. Use of definite, careful selection procedures in hiring drivers.
6. Thorough training of drivers in correct driving practices.
7. Effective control of drivers through proper supervision.

Application of these control factors has a double importance—safety and profit—for weaknesses in the consistent application of any of these basic controls result in such things as accidents, damage to equipment and cargo, delivery delays, poor customer relations, speeding, poor equipment condition, road breakdowns, excessive maintenance, high labor turnover and high operating costs.

John D. Gallagher is a member, Greater Chicago Chapter of the Society. His article is based on more than 15 years of experience in working with motor vehicle fleets as a safety engineer with the Hartford Accident and Indemnity Company.

Selection of Equipment

For example, on a trucking operation vehicles were not being selected properly for the transportation job to be done and, as a result, often were being heavily overloaded. Consequently, brakes and steering mechanisms were in poor condition, and this resulted in some serious and costly accidents.

Also, some of the common conditions disclosed by a survey of this fleet included:

1. Worn steering links and bushings, and loose steering.
2. Spring U-Bolts loose and twisted out of position, and cracked spring leaves.
3. Reduced life of clutches and transmissions due to starting under excess load.
4. Reduced life of brake linings, and poor braking power under excess loads.
5. Excessive gasoline consumption.
6. Reduced life of wheel bearings.
7. A record of excessive road breakdowns.
8. Shortened serviceable life of trucks.

The proper selection of a truck for a specific transportation job is a detailed subject in itself. It involves making a thorough service-requirement analysis to determine the operating characteristics that will be required of the vehicle in service. If the vehicle is to be selected correctly for the transportation job to be done, the service requirements will be determined by such considerations as:

Counseling with a driver often can bring about improvement in attitude and result in better accident record.

1. Whether it will operate over hilly or level terrain, on short or long runs, over smooth or rough roads; with a fixed maximum, variable or diminishing load; whether it will operate in the city, where there is frequent starting and stopping, or over the road, or in intermediate areas.
2. The amount of maximum payload.
3. The steepness of grades traveled, and percentage of total mileage when loaded which will be uphill.

This service-requirement analysis is then used as the basis for determining the specific characteristics that vehicles should have to give efficient service under the operating conditions they will encounter, such as load capacity, braking power, body type and size, wheel base, use of single or dual wheels and single or tandem axles, engine horsepower and R.P.M., type and capacity of rear axle, rear-axle ratio and use of two-speed axles, correct transmission ratios, and optimum number of transmission speeds.

Obviously, if adequate attention is not given to the selection of proper equipment, vehicles will be improperly sized for their service requirements, and experience shows this may result in accidents, poor equipment condition, inefficient vehicle operation, road break-downs, excessive maintenance and other related problems. Also important is the provision of adequate accessories and road emergency equipment.

Scheduling of Equipment

Proper scheduling of equipment involves the assignment of trucks that are in good operating condition, to handle loads within their designed load capacity and within legal load limitations, over runs of the type for which their operating characteristics were selected.

What can happen when improper scheduling occurs is illustrated by the following incident:

A gasoline trucker received a call from a refinery to make a rush delivery. The call came during the peak of the delivery schedule and no spare trucks were available. However, a truck had been brought into the shop for some brake adjustments and minor repairs and, since the vehicle had come in under its own power, the dispatcher sent it on the refinery job rather than wait for another truck.

After loading, the driver started the trip, but did not get far before he ran into a traffic situation that required a fast emergency stop. His brakes did not hold, and a bad accident resulted, with considerable damage to the truck. Also, the truck was delayed at the accident site so that delivery of the rush load was held up longer than it would have been if the dispatcher had waited until a truck in good condition was available. So that, as the result of a weakness in scheduling this run, there was a bad accident, considerable damage to the truck, and a very serious delivery delay.

In his work the dispatcher must not only give consideration to routing of the cargo from the pick-up point to its destination, but also must bear in mind which trucks are available and in closest proximity to the point of pick-up, their size with regard to the legal load limitations of the states into which they may operate, and the working hours of the driver who will be assigned to drive.

It always is important that no driver be dispatched who has not had sufficient sleep. His reactions will be slow in emergencies and, in such cases, it is not uncommon for the driver to fall asleep at the wheel. In the past many serious accidents have resulted from this situation.

Scheduling of hurried deliveries at any time can result in accidents, because the driver then tends to drive faster than is safe for road, traffic, and weather conditions. Also, during the winter when ice and snow cover the highways in many areas, it must be remembered that posted speed limits often are too fast. Unless the driver operates at speeds considerably below posted limits, ice on the road can cause skidding, jack-knifing—and accidents which result in injuries, damage to equipment and cargo, delivery delays, and other excessive costs.

Routing of Equipment

Proper routing of equipment is an important control factor because there are certain street and highway conditions that predispose towards accidents and other operating problems, and are better avoided when possible by the use of alternate routes.

For example, a petroleum contract hauler let his drivers choose their own routes. On one run the driver had a choice between a narrow, winding road with narrow bridges, and a broad, straight road with fewer and broader bridges. Because of a favorite coffee stop, the driver chose the narrow road.

He drove onto a bridge approach just as another truck started through from the opposite end. Because the bridge was narrow, the gasoline driver applied his brakes to allow the other truck to clear first. There was a patch of ice on the bridge approach. His tractor slid onto the bridge and the trailer-tank jack-knifed against a corner of the concrete bridge abutment. The cargo tank ruptured, the gasoline cargo caught fire, the driver was burned up in the cab, and the intense heat of the fire weakened the bridge structure so badly that it collapsed into the river.

If this driver had been required by routing procedures to use the other route that had no narrow bridges, he could not have run into the kind of situation which caused this accident and resulted in loss of his own life,

and the costly destruction of vehicle and bridge.

Accident exposure usually is greater where roads are narrow, winding or hilly; where traffic is congested; at dangerous railroad crossings or street or highway intersections; school zones; narrow bridges. Locations where trucks may be delayed—such as railroad crossings that hold up traffic because of long freight trains and extensive switching operations—also should be avoided, for drivers have a tendency, after delays, to speed to make up the lost time, which results in an increased accident exposure.

Inadequate attention to careful routing may result in speeding, accidents, damage to equipment and cargo, delivery delays, and so on, which combine to create unnecessary operating costs.

Maintenance of Equipment

In some motor vehicle fleets, equipment maintenance consists simply of letting things go until some particular part goes wrong; then that particular item is repaired, and things are let go again until some other item requires repair. However, when various truck parts become worn, their play imposes excessive stress and wear on interrelated parts, which shortens their life and reduces operating efficiency. A haphazard program of "repairs when needed" often proves more expensive in the long run that a program of periodic preventive maintenance which specifies replacement of parts or unit assemblies at definite time or mileage intervals, before troubles show up.

An example of what may happen as a result of inadequate attention to equipment maintenance is the case of a certain wholesale bakery fleet of about 300 trucks. As a consequence of a poor maintenance program the trucks were in generally poor condition, which caused accidents due primarily to poor brakes, defective steering and other equipment defects. Also, a check of their records showed they were averaging 43 road breakdowns a month. Every time they had a breakdown they had to send out a second truck, and transfer the cargo for continued delivery. There also were costs of towing in broken down trucks, delivery delays, poor customer relations and a definite loss of sales.

Optimum efficiency of vehicle operations usually is secured through periodically scheduled preventive maintenance, which generally results in fewer breakdowns and road calls, increased life of equipment, a minimum possibility of accidents due to mechanical failure, and a lower cost of operation.

Selection of Drivers

An example of what can result from poor driver selection procedures may be seen in the experience of a gasoline contract hauler a few years ago when a man applied for a driver's job. During the interview this man made an excellent impression, and indicated he had considerable experience in truck operation.

When asked for his chauffeur's license, he said he had left it at home in his other clothes, but would bring it in later if desired. At the time of the interview there was a truck standing idle in the terminal, and the applicant was hired on the spot and assigned to take the idle unit out immediately.

Witnesses later told how, when he came to a curve in the road, instead of following the road around the curve, his truck kept going straight ahead and piled up in the ditch. The truck, which was carrying a cargo of gasoline, caught fire and burned up, cremating the driver in the cab and also fatally burning a hitch hiker whom the driver had picked up along the way.

Before he died the hitch hiker stated that the driver had done an excellent job of driving up to the point of the curve on the road, but at that point he had some kind of a seizure which caused him to lose control of the vehicle, and resulted in the accident.

Investigation disclosed that the driver had once had a chauffeur's license, but that it had been revoked recently because of epilepsy. The verdict in this case was that an epileptic seizure was responsible for the man's losing control of the truck. A good driver selection procedure would not have put this man to work until after his previous driving and employment record had been checked, and the man had produced a valid chauffeur's license.

In less extreme cases, the experience of some truck operators has been that they were hiring many drivers with bad driving habits. As a result of speeding and following too closely, some of them were hitting bumps too hard, causing tire damage, bent steering arms and even bent axles. They were having to make hard emergency stops that overheated the brake drums and caused other brake damage, that bent the rear spring centerbolts on the tractor, throwing the unit out of line and causing excessive tire wear and hard steering. Some drivers were not double-clutching properly, causing chewed-up transmission gears. Some were not shifting down in gears on grades, so that they lugged the motor, resulting in overheating and damage to the motor. Some were backing in too hard against loading docks, causing banged-up rear ends on trailers and bent rear-spring center-bolts on the tractor. These bad driving practices, resulting from poor driver selection, also were responsible for frequent accidents, and necessitated excessive maintenance.

Recognized good practices in the selection of drivers require a satisfactory interview with the applicant; refer-

Complete accident record on each driver is a must to form intelligent basis for retraining, counseling or penalizing when necessary.

ences which will show a good record with regard to driving and other employment experience, when checked; and an applicant should be given a road test in which his driving ability and habits can be evaluated. Some companies give applicants written tests on traffic knowledge, intelligence or attitude. All applicants should, of course, pass the I. C. C. physical examination. Hiring often is on a probationary basis, so that any men who are not up to standard can be released before the date when the union contract gives them permanent status as drivers.

Training of Drivers

The thorough training of drivers is especially important in trucking. In a factory a supervisor can observe the operations of his men and correct unsafe or poor work practices at the time they occur. A truck driver, on the other hand, is out on the streets or highways, and away from supervision. That also is where his accidents happen, and so thorough training must be relied on for proper control of his operations.

One dry freight carrier hired some new drivers, and gave these men practically no training. One of these new drivers had had considerable driving experience, but it had all been on straight trucks on a city operation. One of his first runs was in bad weather over a hilly route with a tractor-trailer unit. While going down an icy hill he failed to apply his trailer brakes properly. As a result he jack-knifed and slid across the road, head-on into an oncoming car, smashing up the other vehicle and seriously injuring three people in it; and then he slid on into the ditch, with serious damage to his own unit and cargo.

One item of cargo was an especially built machine that the consignee was anxious to receive at his plant and set up in production as soon as possible. This machine was damaged to such an extent that it had to be sent back to the factory and rebuilt, which meant a considerable delay in delivery, and also resulted in poor customer relations for the carrier.

In this case failure to train drivers adequately resulted in an accident, damage to equipment and cargo, a serious delivery delay, and poor customer relations.

Good training develops good work habits. When a new truck driver is hired, it is important that he develop good habits of operation. In order to accomplish this, training should start as soon as the man comes on the job, and it should continue, in one form or another, pretty much throughout his entire period of employment.

When a man is not well trained he is apt to make mistakes, and in truck operations mistakes can result in accidents, damage to equipment and cargo, delivery delays, poor equipment condition due to bad driving practices, poor customer relations, excessive maintenance—which all contribute to high operating costs.

Supervision of Drivers

It is essential that the fleet safety director receive full backing and cooperation from top management, and from other supervisors, if the accident control program is to function smoothly and produce constructive results.

In truck operations, as in most other lines of business, men do their best work when their activities are well supervised. Where supervision is weak drivers often develop bad driving habits and other slipshod methods, which mitigate against safe and efficient operation. Where this condition exists many opportunities are lost to improve the profit margin by reducing accidents and other operating costs which result from driver inefficiency.

Any supervisor gets his results by working through people, and he must work effectively with his people to get good results. The supervisor usually gets his men to do what he wants done, when he wants it done, and in the way he wants it done, because his good relations with these people make them want to do the job his way.

The efficient management of any business depends on an exercise of proper control over men, materials and equipment, and this control depends, to some extent, on the use of records. The keeping of accident records and costs is important to accident reduction, and for the supervision and control of drivers, as well as being a source of information for handling claims.

On each accident a detailed, written report should be made out by the driver involved, preferably with the assistance of the safety director, or otherwise of the local terminal manager. Accident reports and records should show clearly the unsafe acts of drivers and unsafe conditions of vehicles involved, and should suggest the ways in which these accident causes can be corrected to avoid any repetitions. This information should be related back to the basic control factors in which weaknesses exist, and then appropriate corrective action should be taken to correct these basic weaknesses.

Experience shows that when drivers do develop poor driving practices and slipshod job habits because of weak supervision, these result in such things as speeding, accidents, damage to equipment and cargo, poor customer relations, poor equipment condition, excessive maintenance, and so on, all of which add to operating costs.

Summary

In this discussion of the seven basic control factors, it may be noted in each case that accidents arise out of the same sources that also produce other operating inefficiencies and excessive costs. That is, accidents arise out of some weakness in applying one or more of these basic factors, and this weakness also is the source, at the same time, of the various other types of operating problems referred to.

For example, poor driver selection, training, or supervision may result in bad driving practices that cause accidents, poor equipment condition, road breakdowns and excessive maintenance. These undesirable problems all can be corrected, not alone by retraining the individual drivers involved, but by basic improvement of the weaknesses in existing practices with respect to driver selection, training or supervision.

That is, constructive basic correction obviously lies in improved application of the seven control factors. This correction contemplates a consistent program of accident investigation and periodic accident analysis and study, combined with a continuing study of weaknesses in operating controls. Pinpointing those control weaknesses which may exist, as part of a well organized and administered safety program, paves the way to their correction. Sources of both accidents and other related operating problems are eliminated or minimized through better control over common accident sources.

The American Society of Safety Engineers
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AFFILIATE MEMBER—The Society also provides a special classification, that of Affiliate Member, for those not professionally engaged in safety engineering, who have demonstrated achievement in a related field.

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